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BURNING-STANDING METHOD of BARKBEETLE CONTROL

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INTRODUCTION.

To determine the actual effectiveness of the burning-standing method of control as practiced against outbreaks of the mountain pine beetle in lodgepole pine, a study of the control work on the Wyoming National Forest was instituted by the Bureau of Entomology in the spring of 1931. It is the purpose of this report not only to present the result of this investigation, but to discuss the place of this method of control in the protection of our lodgepole pine forests against the ravages of the mountain pine beetle.

The writer wishes to acknowledge the cooperation and assistance given to the Bureau of Entomology by the members of the Forest Service. Every possible effort was made by these officers to contribute towards making this study a success. Indebtedness to Messrs. Gibson, Terrell, and Bedard of the Coeur d'Alene station who gave valuable assistance to the writer in computing the data secured, is also acknowledged.

DEVELOPMENT OF THE BURNING-STANDING METHOD OF CONTROL

The first attempt to utilize fire in destroying broods of the mountain pine beetle in standing lodgepole pine trees was made in 1925 by Mr. W. W. White, Forest Service, Missoula, Montana, in connection with control work being conducted in the Bitterroot National Forest. In these first attempts a "Houck" torch was used

with the burner on the end of a short extension. With this equipment it was possible to scorch the lower ten feet of the bole, which was fairly comparable to the peeling-standing method of control which was being practiced at that time. However, this experiment, though effective in destroying the insect broods beneath the bark on the scorched portion of the bole, proved to be slow and expensive, and was abandoned as being impracticable. Mr. White then attempted the burning of large, heavily limbed, standing trees by placing a few long, dead poles upward against the bole of the tree in tepee fashion, and then building a fire at the base with forest litter. This plan was very effective, the flames being often carried up along the poles through the crown. It was possible for one man to treat a number of such trees each day, and large numbers were burned in this manner during the following two seasons of control in the Big Hole Basin.

The utilization of an inflammable oil sprayed upon the bole of standing, infested trees as a means of control, was first tested by Mr. White during the Big Hole Basin control project in 1926. These tests were not very extensive, and only a few trees were treated with two different grades of fuel oil and kerosene. These tests were made one evening and a preliminary examination on the following day revealed the fact that a rather large percent of the immature insects in the burned portion of the hole had not been destroyed. However, a subsequent examination made a few weeks later showed that all of the insects had succumbed to the effects of the treatment. In 1927 additional tests were conducted, which proved to be very satisfactory. It was not

expected that this method of control would displace the felling, decking, and burning of infested logs which was being practiced in the Big Hole Basin at that time, but that it could well be used as an auxiliary method for the treatment of the large, heavily limbed trees. Such trees are the most expensive to fell, deck, and burn, but are susceptible to effective treatments by the burning-standing method. The cessation of the Big Hole Basin project at the close of the 1928 season prevented the testing of this dual plan of control.

During the 1928 season, forest officers in attacking a scattered infestation of the mountain pine beetle in the lodgepole pine stands of the Targhee National Forest, utilized the burning-standing method of treatment. During the next three years this method of control became a standard practice on the several forests of Regions 1 and 4, as well as the Yellowstone Park, where projects combating outbreaks of the mountain pine beetle were instituted. During this three year period the forest officers of Region 4 developed marked improvements in the method through the use of pressure tanks, extensions, nozzles, and oil, as well as in the technique of application.

THE BURNING-STANDING METHOD OF CONTROL

The burning-standing method of control consists in spraying an inflammable oil upon the bole of infested trees, which are then burned. The oil adopted as best meeting necessary requirements, is a fuel or gas oil, with a specification of 32 to 34+ gravity, and a flash point of approximately 160° F. Kerosene has a lower flash point and

burns more freely during cold weather and days of high relative humidity though it does not satisfy other requirements. Furthermore, as burning-standing is not effective in wet weather and should not be used at such times, gas oil has been used during the past two seasons.

Oil is thrown upon the trees from a five-gallon pressure tank through a nozzle designed to produce a fine solid stream. Some of the tanks are equipped with a six-foot, steel tube extension, while others have but a short 24" hose. The technique which is used in spraying the trees is to have the burners work in pairs. One tank with an extension is used to apply the oil to the bole of the tree above the point which can be reached by the other burner. With the aid of the extensions an additional, sprayed height varying from 7 to 9 feet, is secured. After the tree has been properly sprayed on all sides, both burners see that there is oil within their tanks and that sufficient pressure is available before the fire is started. A lighted match is then applied to the base of the tree and the flames carried upward with the aid of a little, additional oil. Just as the flames reach the top of the sprayed portion of the bole, more oil is thrown at this point through the extension, which in many instances, develops sufficient heat to force the flames upward through the crown.

Different methods for distributing the oil through the woods are used. Where the infestation is of sufficient intensity to justify separate operations for spotting and treating, oil is taken from the camps into the woods in 50-gallon drums by means of "Lizzards" or "Go Devils", and cached near the different groups of trees which are to be

treated. Hand carriers then transport the oil from these drums to the burners. Where the terrain is so rough as to prevent the hauling of 50-gallon drums, pack trains are used, with specially adapted packs. Different sorts of metal containers have been tested, but it has been found that heavy 5-gallon cans, in strongly constructed boxes, make the most satisfactory side pack. Twenty gallons per pack animal are transported in this manner.

When faced with light scattered infestations, spotting and treating are performed in one operation. Under such a plan of operation a pack train equipped with spray tanks, extensions, tools for felling tall trees, and oil, follow the spotters, and the trees are treated as encountered.

When these methods are carefully planned, there need be but little time lost through waiting for oil. Over rough portions of the terrain, where pack horses can not travel, it is often necessary for the spotters to carry their spray tanks filled with oil. This practice, though necessary under certain conditions, should be avoided whenever possible, as the carrying of these heavy tanks materially reduces spotting efficiency.

EFFECTIVENESS OF BURNING-STANDING CONTROL

Although a large percentage of the trees can be satisfactorily treated through a straight burning-standing plan of operation, 100 per cent control can not be secured, for with the present equipment , the oil can not always be thrown to the height of the infestation. Furthermore, unless the entire crown is consumed by the fire or the trees burned

to a small top diameter, it is difficult to determine the effectiveness of the treatment, as one can not be sure of the height to which the infestation extends.

On many of the areas where this method has been used in combating outbreaks of the mountain pine beetle, an annual reinfestation has occurred, the source of which has been somewhat intangible. The improperly treated base and tops of trees were advanced as one of the sources of supply for this reinfestation. To properly weigh this factor, as well as to secure certain information which could be utilized in making the method more effective, a detailed study was planned by the Bureau of Entomology in the spring of 1931.

RESULTS OF 1931 INVESTIGATION

The work in connection with this study was located on the lower units of the Greys River Insect Control project, Wyoming National Forest. This area was selected upon the advice of Mr. C. B. Morse, Assistant Regional Forester, as being best adapted to a study of this character. This investigation was under the field supervision of Mr. L. G. Baumhofer, Assistant Entomologist, who was assisted by Messrs. Foley and Farmer, temporary appointees of the Bureau of Entomology. As Mr. Baumhofer was obliged to return to his work at Halsey, Nebraska, early in June, he was relieved by Mr. T. T. Terrell, of the Coeur d'-Alene station, who completed the work as planned. The writer arrived at Greys River Camp #1 on May 17, 1931, where the following plan of operation was instituted.

Though several plans for studying the burning-standing method of control were available, it was decided to concentrate upon an examination of trees which had been treated by the regular burning crews, rather than attempt the testing of trees treated under controlled conditions. In following this plan all trees, regardless of size, height, location, severity of infestation, etc. which had been treated by the regular crews, were felled and examined.

Trees were taken as located, no selections being made. From these examinations the following data were taken:

D. B. H.
Height of tree
Height of attack
Height of brood
Severity of basal attack
Height of average burn
Diameter top of brood
Diameter top of average burn

Many large trees which were considered as being too tall to treat satisfactorily by burning-standing, were felled and treated by spraying oil along the trunk for burning. Examinations were made of a number of these trees to determine the effectiveness of the method, as well as to secure data relative to the character of the infestation.

Trees were felled for examination in three different areas, as follows:

AREA #1

Location -
Date of treatment - May 8 - June 1, 1931
Date of examination - May 18-June 3, 1931

AREA #2

Location -
Date of treatment - June 1-15, 1931
Date of examination - June 4-18, 1931

AREA #3

Location -
Date of treatment - May 8-16, 1931
Date of examination - June 22-29, 1931

The following table shows the data secured from these three areas.

TABLE SHOWING RESULTS OF EXAMINATIONS OF TREES

TREATED WHILE STANDING

Table #1

		AREA I.	AREA II.	AREA III.
Number of trees felled for examination		140	48	143
Number of trees with brood above burn		45	4	54
Percent of trees with brood above burn		32%	8%	38%
Average D. B. H.	(Total trees examined	12.9"	9.5"	12.7"
	(Trees with brood above burn	12.9"	10.8"	11.8"
Average Height	(Total trees examined	69.4'	49.5'	67'
	(Trees with brood above burn	70.4'	52'	65.7'
Average Height of Attack	(Total trees examined	26.8'	22.6'	27.2'
	(Trees with brood above burn	39.0'	33.0'	32.8'
Average Height of Insect Brood	(Total trees examined	23.6'	19.6'	24.4'
	(Trees with brood above burn	36.6'	32.5'	31'
A verage Height of Burn	(Total trees examined	27.0'	26.9'	31.7'
	(Trees with brood above burn	24.5'	27.0'	27.9'
Average dia. top of burn	(Total trees examined	10.1"	5.7"	7.8"
	(Trees with brood above burn	10.7"	9.5"	9.5"
Average dia. top of Brood	(Total trees examined	10.3"	7.0"	9.7"
	(Trees with brood above burn	8.9"	8.5"	8.5"
Average length of infested bole above burn		12.2'	5.5'	7.7'
Percent of total infested length untreated		16.8%	2%	12%
Percent of total infested length treated		83.2%	98%	88%

The data as secured from these examinations can not be considered as a test of the burning-standing method of control. The work as conducted in 1931 was a modification of the method, as all trees which in the judgment of the crew foreman could not be burned to the height of infestation, were felled for treatment. As a result of this modification the trees which were treated standing, and from which the data were secured, were the smaller ones which the crew foreman believed were treated in a satisfactory manner. Therefore, the data do not present an actual test of the burning-standing method of control as previously practiced. A better picture of the effectiveness of the method can be secured if the average height of burn, secured on the standing trees, is applied to the average height of brood on both the trees treated while standing, and those felled for treatment. Of the trees felled for treatment, 236 were examined. These data added to those secured from the trees treated while standing, show an average height of brood of 41.9'. The average height of burn on all three areas was but 29 feet, which when applied to the average infestation would leave 12.9 feet of infested bole untreated. However, this is not a sound conclusion as the average burn was based upon the treatment of the smaller trees, where in many instances it was considered unnecessary to attempt to secure a maximum treatment. It can be expected that the average height of burn would have been increased somewhat had all of the trees been treated standing. So in reality the studies as conducted can only be considered as being directed towards the testing of the modified method of burning-standing control as practiced in 1931.

In the above tabulation there are a few items which require some explanation. The height of attack was measured by the highest pitch tube, while the height of brood is determined by the presence of insects. As the uppermost attacks are often pitched out, or else are unsuccessful in development, there is usually a difference of several feet between these two points.

From this table it will be seen that for all of the trees examined, the average height of burn is above the average height of brood, and yet in all of the areas there was infested bark surface left untreated. This is, of course, explained by the fact that the figures as given are but averages, and that untreated bark surface occurred in trees with higher infestations, which were above the average burn, as well as the individual burn of those particular trees. Furthermore, no relation existed between the height of burn and the height of infestation as many trees were burned above the height of brood as well as below.

In the modified burning-standing method of control, it was assumed that the larger, taller trees constituted the greatest danger and were selected for felling and treating. Though this practice was sound as the trees selected for felling on Area I and II showed a greater/average infested length (Table #II), it was not the case with the trees which were treated standing. In Area I the D. B. H. of the trees treated standing with insect above the burn, were of the same general average as those which were treated satisfactorily. In Area II they were 1.3" larger, while in Area III, they were .9" smaller.

This can only be explained by the variation in the height of infestation as well as the burn.

It will be noted that there is quite a difference in the data from Area II and that from I and III. In other words the results obtained from Area II appear more satisfactory. This is quite true, and is explained by the fact that before treating was started in Area II, information secured from this study in Area I had been made available, which resulted in a tightening up of the method with more trees being felled for treatment. As a result of this action the work as conducted in Area II was practically 100% effective. It would therefore seem necessary to consider the data from Area II as representing satisfactory control, and to use it as a check for the results secured from Area I and III.

The comparison between the average height of burn and the height of brood is rather interesting, and presents the difficulty of determining the actual height to which a tree should be treated. In Area I the average height of burn on the trees with untreated bark surface was only 24.5 feet, while the height of brood was 36.6 feet. In Area II there were 27 feet of burn with 33 feet of insect-brood; Area III showed 27.9 feet of burn with 31 feet of insect-brood. In Areas I and III the burns on the trees with untreated bark surface were lower than the average burn for the entire area, which would indicate rather clearly that the crew foremen had assumed that these trees had been treated satisfactorily.

A peculiar fact was revealed during this examination. It has been thought that the intense heat which arises from the burned portion of the tree would in many instances be sufficient to destroy the broods for a short distance above the actual burned surface. This did not prove to be true, for the mortality of the broods ceased abruptly at the edge of the burn, and in no instance were dead insects recorded above a point where the bark had been burned sufficiently severe to turn the edges of the bark flakes white.

These data show that 12.59 per cent of the total infested length was left untreated on those trees whichwere considered as being properly treated while standing. However, this figure can not be considered as representing the per cent of actual brood which was left untreated. A previously conducted detailed analysis of the broods of the mountain pine beetle, shows very clearly that the heaviest broods are in the lower portion of the bole, and that there is a rather constant decrease in the number of insects per square foot of bark surface for each additional height of infestation. Furthermore, the figures in this report indicate the lineal length of infested bole left untreated with no consideration being given to the difference in the area of bark surface, as a result of the smaller diameters in the upper portion of the bole. When these two correction factors are applied to the data as shown, the per cent of brood left untreated is reduced to 3.9 per cent.

Going still further, and rather to an extreme in trying to show the effectiveness of the burning-standing method of control, the

data from Area I is used as an example. If it is assumed that the trees felled for treatment, had been treated standing and in applying the average burn of 27 feet, which was secured within the area, we would have the following data.

Total Height of Insect Broods (140 trees felled for treatment, 36 treated standing)	4,875 feet
Total Height of Burn -- -- --	3,729 "
Total Untreated Length of Bole -- --	1,146 "
Per cent of Total Infested Length Left Untreated --	23-1/2 %

As stated this does not mean that 23-1/2% of the brood was left untreated, for when this length of the upper portion of bole is reduced to actual brood figures, there would be but 8 - 10.5% of the total brood left untreated had all of the trees in Area I been treated standing. This figure is based upon detailed brood counts from 104 trees examined in the Bitterroot National Forest.

COMPARISON OF TREES TREATED STANDING

AND THOSE FELLED FOR BURNING

Table No.2

		AREAS I.	II.	III.
Average D. B. H.	standing	12.9"	9.5"	12.7"
	felled	16.3"	12.1"	---
Average height of tree	standing	69.4'	49.5'	67'
	felled	83.5'	64.2'	---
Average height of brood	standing	23.6'	19.6'	24.0'
	felled	43.5'	29.1'	---
Average dia. top of brood	standing	10.3"	7.0"	9.7"
	felled	10.6"	8.6"	---

The above table sets up a rather marked difference in the trees felled and those treated while standing. The average D. B. H. and height of felled trees are greater than those of the standing trees, which is as expected, because the larger trees would be considered as constituting the greatest danger. There is also a marked difference in the average height of brood, which would support the selection of these trees for felling. The little difference which exists in the average diameters at the top of brood, indicates a relationship between the height of brood and the size of the tree. Of the 236 felled and treated trees, which were examined, only 21 showed live broods above the burn with an average, untreated length of 2.5 feet. Though this was not of great importance, it was, no doubt, due to an improper decision as to the height of brood.

SEVERITY OF BASAL ATTACK AND D.B.H.
AS AN INDICATION OF THE HEIGHT OF BROOD.

The following table shows the height of brood for different diameters grouped in 3 inch classes, in relation to the per cent of the basal circumferences attacked.

Per cent of circumference attacked	Diameters of 3" Classes				
	6-8	9-11	12-14	15-17	18-19
	AVERAGE HEIGHT OF BROOD				
100% 4 sides	21.65	28.36	32.77	36.96	34.95
75% 3 sides	16.94	21.33	24.58	26.38	44.33
50% 2 sides	18.5	18.48	23.61	21.79	19.50
25% 1 side	13.8	13.84	13.73	19.70	9.00

With the exception of the 18-19" Dia. Class, the 4 sided attacks show, as would be expected, the highest infestation. The difference in the larger diameter class lies in the fact that only a small amount of data was available. In addition to the per cent of the basal circumference attacked, the character of the attack is perhaps an even better factor of measurement. The trees with heavy, basal infestations, where the inner bark has been completely destroyed by the feeding larvae, will have a greater height of brood than those with light attacks. The character of the blue stained sapwood can also be used as an indicator of the severity of the attack.

The following table shows the height of infestation for heavy, medium, and light blue stain, as compared to the 3" Diameter Classes. In making these examinations, the intensity of blue stain was recorded for each side of the trees, and as this data varied for the different sides, a statistical weight was given to each measurement, from which the average for each tree was secured.

Average degree of blue stain of the entire basal circumference	Diameters of 3" Classes				
	6-8	9-11	12-14	15-17	18-20
	AVERAGE HEIGHT OF BROOD				
Heavy blue stain Sapwood all dark blue	23.06	29.81	34.34	39.31	32.28
Medium blue stain Sapwood not all dark blue	17.88	21.63	27.22	29.76	43.00
Light blue stain Sapwood lightly blued	14.40	16.29	15.50	20.85	10.66

The above data shows practically the same correlation as secured from the difference in the number of sides attacked. The same difference, due to insufficient data, exists with the 18-20 diameter class.

DIAMETER AS AN INDICATION OF THE HEIGHT OF BROOD.

The following table shows the average height of broods in relation to the different basal diameters. These diameters were arranged in 3" Diameter Classes due to the rather small amount of data available.

Based on 543 Trees.

3" Diameter Class	6-8"	9-11"	12-14"	15-17"	18-20"
Average Height of Brood	19.0'	23.13'	28.51'	29.82'	33.07'

A similar table has been made from the data secured during studies of the mountain pine beetle in the Bitterroot and Beaverhead National Forests.

Based on 358 Trees

3" Diameter Class	6-8"	9-11"	12-14"	15-17"	18-19"
Average Height of Brood	26.75	34.33	43.37	58.3	55.0
No. Trees	20	184	141	11	2

These two tables show the same general correlation between diameters and height of brood, though the data from the Bitterroot indicates a much greater height class.

THE PLACE OF THE BURNING-STANDING METHOD OF CONTROL IN THE PROTECTION OF LODGEPOLE PINE FORESTS

A comparison of the burning-standing method of control with others which have been practiced, presents a difficult task. Such a comparison must be based upon the effectiveness of the methods and their cost of operation in combating outbreaks of the mountain pine beetle. With all projects there exists such variable factors as transportation, nature of terrain to be covered, density or severity of infestation, weather, and personnel, so that each operation must be considered on its own merits, and a method of control adopted which would appear best suited to the factors involved.

In attempting to compare these two methods, which have their own place in a program of protection against the ravages of barkbeetles, all that the writer feels capable of doing is to offer a few suggestions which can be utilized in weighing the different factors involved, so that the most effective method of control can be selected.

Effectiveness of two methods

Though the felling, decking, and burning method as practiced in the Big Hole Basin is considered as securing a 100% control of each tree treated, there would seem to be no reason why burning-standing can not be modified sufficiently to give the same results. However, a straight burning-standing program, based upon available data, could not be considered as being as efficient as felling, decking, and burning, the degree of efficiency varying with the height of the trees being treated.

Cost of Operation

The cost of straight burning-standing is difficult to compare to that of felling, decking and burning, because of the difference in the effectiveness of the two methods. However, the cost of the modified burning-standing as practiced in 1931, varied from $1.03 per tree on the Cache to $3.69 on the Madison. The costs on the Madison, however, were increased somewhat due to unfavorable weather conditions. During the season of 1928, some 55,000 trees were felled, decked, and burned in the Big Hole Basin at a cost of $1.62. A comparison of these two figures would be very unjust as in the Big Hole Basin, a heavy infestation with large groups of infested trees, was being combated; while in 1931, the control work was for the most part directed against scattered, rather light infestations. In combating heavy infestations where the infested trees occur in groups, it is believed that the cost of felling, decking, and burning, will compare favorably with the burning-standing method of control, modified sufficiently to insure a comparable treatment. With light infestations which require a plan of operation calling for a combination spotting and treating crew, the modified burning-standing will, no doubt, prove more economical in most areas.

Fire Danger

Though these projects are conducted during a season when the fire danger is not acute, precautions must be taken if destructive fires are to be prevented. This danger is, no doubt, greater with

the burning-standing method than when the trees are felled and decked in small openings, etc. When a tree is burned standing, or is felled and burned as it lies by spraying oil along the bole, fires are often started in piles of debris around the base of the trees, or in old logs, brush piles, etc. on which the tree has fallen.

During the three years that felling, decking, and burning was practiced in the Big Hole Basin, the area burned was practically nil, while some rather severe fire losses have occurred through the use of the other method. However, such a comparison is again rather unfair, as the two methods were used under different circumstances, and in forest types of different inflammability. In the Big Hole Basin a heavy infestation was being combated, and a treating crew would be located within an area for a period of several days, so that fires were under daily observation and all spreads prevented. Such surveillance is not feasible with the burning-standing method as it is necessary for the crew to leave each tree soon after it is treated. Though in practicing this method all fires are supposed to be left in a safe condition, holdovers are common and losses occur. It is believed that some of these losses could have been prevented by exercising more care in putting out the fire at the base of the trees at the time of treatment, and by burning during the morning and evening hours of the day. Though there is a fire damage to be met in the use of both methods, it is believed burning-standing offers the greater problem.

Selection of Method

Though in areas where both methods could be utilized, the objective of the project should be considered before a plan of operation is made. If funds are available for a complete clean-up of the infestation, the felling, decking, and burning method, or a severely modified plan of burning-standing, should be adopted in order to secure a 100% control of the trees treated. However, if only a limited portion of the area can be covered with the funds available, a straight burning-standing program of control will undoubtedly destroy the most insects for each dollar expended. This position is based upon the data submitted within this report, which would indicate that a large per cent of the insect brood will be destroyed through the treatment of the lower 25' of the bole.

Flexibility of the Two Methods

Though both methods can be adapted to different plans of organization, the burning-decking method would perhaps have its greatest use in the control of heavy infestations, where horses could be used for the skidding of the infested logs. However, it could be used by a combination spotting and treating crew through the hand logging of the infested trees. On the other hand, where directed against a scattered infestation, such as would require a combination crew, many small, single trees are encountered which would necessitate felling and decking, and would result in the leaving of small scattered fires which would burn for some hours. Many small trees can be treated successfully by piling brush around the base with a dead pole

or two extending into the crown to carry the flame into the lower limbs.

Burning-standing can well be adapted to the combination spotting and treating crews, which were rather commonly used in 1931, as when isolated trees are burned standing, the fires can be extinguished before they are left. However, with this method tools must be carried for the felling of the trees which are too large to be treated successfully while standing.

No attempt has been made to adapt the felling-decking method of control to a mobile spotting and treating crew, and though the writer does not know that it can be done, it would seem hardly fair to condemn the method until some thought has been given to it. However, there can be no doubt but that burning-standing is best adapted to such plans of operation.

In summarizing these points it would seem that though the plan of control must be based upon the conditions encountered with each project, the burning-standing method of control as modified in 1931, offers the greatest possibilities of use. However, the cost of this method, which was the greatest argument in its favor when straight burning-standing was practiced, has been increased through the necessity of felling a certain per cent of the trees, so that it is doubted if it would be below that of felling and decking in areas where the latter method is feasible. Burning-standing should not be adopted as a standard procedure, for it is believed that there are many areas where the trees could be felled and decked for burning more economically than they could be treated by the modified method of burning-standing as practiced in 1931.

SUMMARY

The outstanding result of this investigation is the effectiveness of the modified burning-standing method of control as practiced in 1931. The effectiveness of the method depends upon the proper selection of the trees to be felled for treatment, and this selection is difficult to make. There is no rule, other than a safety first procedure, that can be offered as a means of determining which trees can not be treated satisfactorily while standing. It is impossible for anyone to accurately determine from the ground the height to which a tree is infested. Though the larger and taller trees offer the greatest potential danger, many of these with smaller diameters harbor broods reaching to a height above that which can be properly treated from the ground. In Areas I and III where modified burning was practiced on the basis of the burner's judgment in selecting trees for felling, 34.9 per cent of the trees which were considered as being satisfactorily treated while standing, were found to contain brood above the height of the burn. It would seem that the only safe rule that can be adopted is that of treating to a definite top diameter limit. From the table on page 15 it will be seen that but little difference existed in the diameters at the top of brood of the trees burned standing and those felled for treatment. This would indicate a rather positive correlation between the average height of brood and the average diameter at that point. To treat all of the trees to an average height of brood, or to

to the average diameter at the height of brood, would leave 50 per cent of the trees with untreated, infested, bark surface above the burn. On the other hand, to treat all of the trees to the maximum height of brood will call for a large per cent of unnecessary work in order to destroy a small per cent of the insects. Obviously, there is a line between the average and the maximum top diameter to which the trees should be treated. The following table shows the per cent of the total number of trees examined which had insect broods reaching to the different top diameters:

Top dia. of trees Inches	4	5	6	7	8	9	10	11	12-19	TOTAL
Number of trees	10	30	51	84	87	56	60	46	131	555 Trees
Per cent of trees with brood reaching to top dia.	1.8	5.4	9.2	15.1	15.7	10.1	10.8	8.3	23.6	100%
Accumulative per cent of trees with brood reaching to top dia.	1.8	7.2	16.4	31.5	47.2	57.3	68.1	76.4	100.0	
Brood left untreated if burned to above top dia.	.1	.3	1.4	4.7	11.2	-	-	-	-	

From the above table it will be seen that only 7.2% of the trees would have brood reaching above a 6" top diameter, 16.4% above a 7". and 31.5% above an 8". When these figures are reduced to terms of brood potentials, we find that the 7.2% of the trees infested above a 6" top diameter would mean that there was only .1% of the brood above this point, .3% above a 7" top diameter, and 1.4% above an 8".

There are a few rather salient points demonstrated by this investigation which should be borne in mind when practicing burning-standing, these are as follows:

1. Determination of the actual height of brood of standing trees is impossible.

2. A relationship exists between the average height of brood and the diameter of the bole at that point.

3. Infested trees occurring in groups are liable to be infested to a greater height than single trees.

4. The larger and taller trees have more possibilities for greater height of brood than those with smaller diameters.

5. Trees treated up to a 7 inch top diameter will destroy 99.7% of the infestation.

6. Trees with heavy basal attacks show higher average infestations.

7. Trees attacked on one side only seldom show a very high infestation.

8. In order to destroy the insects beneath, it is necessary to burn the bark so severely that the edges of the bark flakes appear white.

9. Trees with heavy bark need especially heavy treatment. Brush or limbs thrown around the base of the large trees insures a thorough treatment at the base, and assists in forcing the flame up the bole.

10. Effectiveness of a straight burning-standing method of control in an attempt to secure a 100% cleanup of the infestation, is questionable. Available data show that but approximately 90% of the infestation as existed within the areas where these examinations were made, would have been destroyed by this method of treatment.

11. A straight burning-standing method of control would seem to be an economical procedure where funds are not available for a complete cleanup of the infestation, as it is believed that from this method the greatest number of insects are destroyed for each dollar expended.

12. A method of control should not be selected without first carefully considering such factors as the plan of operation necessary, character of the infestation being combated, fire danger, character of the terrain, transportation, and personnel.

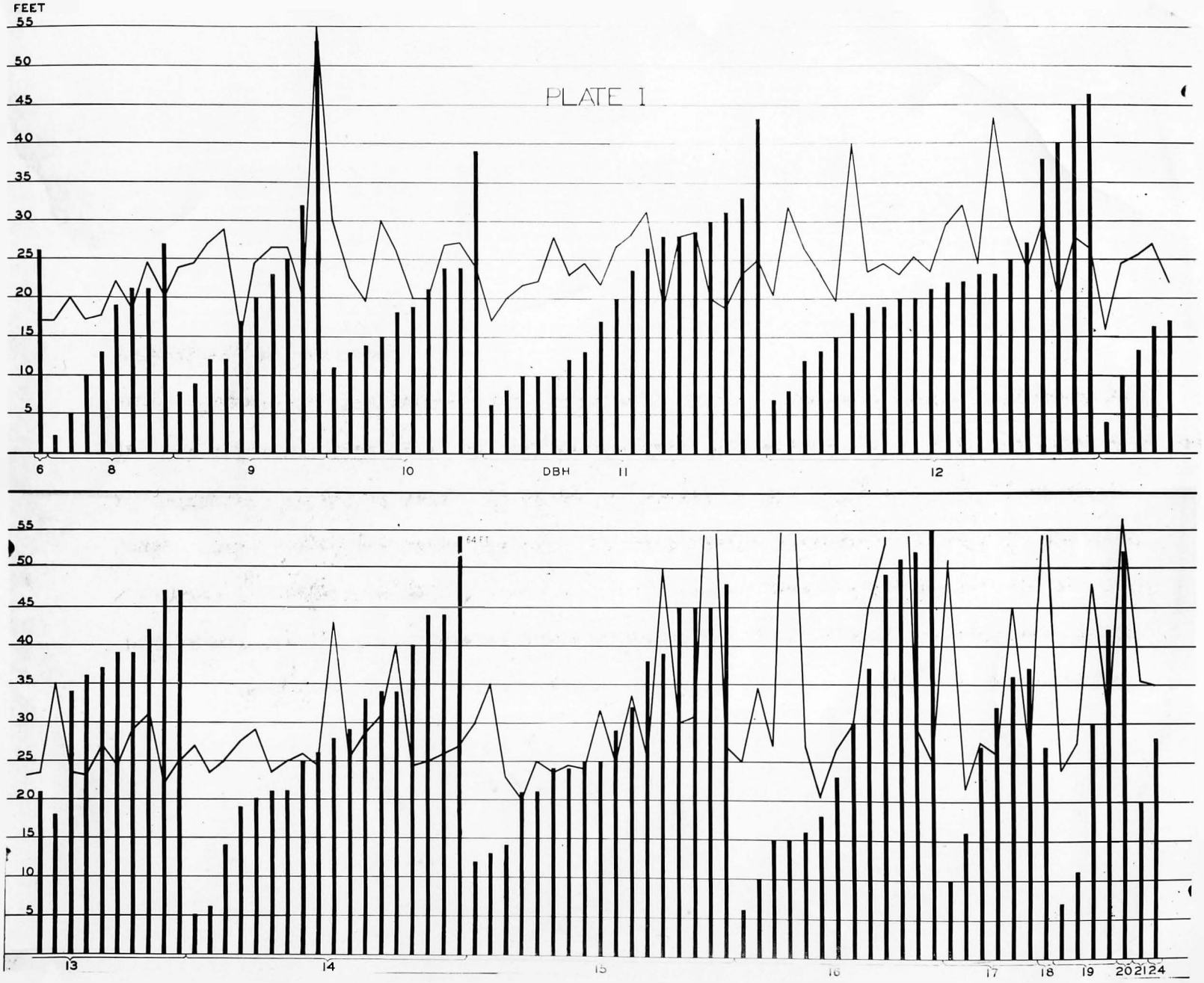
13. With the development of more effective spraying equipment which will throw the oil to a greater height, more trees can be treated to a satisfactory top diameter. This reduction in the number of trees which would otherwise require felling, would correspondingly lower the cost of the operation.

Respectfully submitted,

James C. Evenden, Entomologist.

P L A T E I.

This graph shows a comparison between the height of brood and the height of burn secured on 145 trees treated standing on Area #1. The heavy, perpendicular lines represent the actual height of brood while the curved line the height of burn for each tree. This comparison shows the over, or unnecessary treatment, as well as the lack of sufficient height of burn. It shows the spread in the different heights of brood for the different diameters, as well as the fact that better treatments were secured on the large diameters. The sharp, extreme rises in the burn indicate those trees which were crowned out by the flames.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